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**USSR REPORT**  
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 No. 53

This serial publication contains articles, abstracts of articles and news items from USSR scientific and technical journals on the specific subjects reflected in the table of contents.

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## OPTICS

### ANALOG OF FARADAY EFFECT DISCOVERED IN CRYSTALS

Kiev PRAVDA UKRAINY in Russian 23 Mar 79 p 3

[Article by TASS Correspondent R. Akhmetov: "A Discovery by Soviet Scientists"]

[Text] A new discovery in solid state physics has been made by Soviet scientists. It was registered with the USSR State Committee on Inventions and Discoveries on 22 March.

It has been known for a long time that under the influence of a magnetic field the polarization of light passing through a crystal is changed, i.e. the plane of vibration of the light waves is rotated. This physical phenomenon is called "artificial optical activity in a magnetic field" or the "Faraday effect."

The expanding field of quantum electronics requires additional methods of controlling light, particularly laser beams. After many years of joint investigation of the electrooptical properties of crystals, Dr of Physical and Mathematical Sciences I. S. Zheludev, a laboratory manager of the Institute of Crystallography, USSR Academy of Sciences, and O. G. Vloch, Docent in the Department of Experimental Physics, L'vov University, have discovered a fundamentally new phenomenon. They have established that artificial optical activity may arise or change in intensity when a crystal is under the influence of an electrical field as well. This is made possible by characteristics of the crystal's structure and its electron states.

The authors of the work have amassed a rich collection of experimental data which they obtained using domestically-produced lasers and high-sensitivity photoelectric methods for determining the polarization parameters of light.

This discovery by the Soviet scientists has evoked considerable interest abroad and has gained worldwide scientific recognition. The results of their investigations have been confirmed in the scientific centers of the CSSR, the USA, England, West Germany and Japan.

The new phenomenon is of great scientific and practical importance. It considerably expands the knowledge of crystal properties and makes it possible to delve deeper into the subtle processes which occur within them under the influence of an electric field. This fundamental work by Soviet specialists has

stimulated the development of effective methods of studying the structure and properties of semiconductors, dielectrics and other varieties of crystals.

The discovery is also of practical value. It can be used in various areas of quantum electronics, holography and optical systems for the transmission, storage and processing of information.

3480

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UDC 534-8:534.311.33

## NONLINEAR EFFECTS IN THE PROPAGATION OF HIGH FREQUENCY SOUND THROUGH NORMAL CONDUCTORS

Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 128 No 1, May 79 pp 107-133

GAL'PERIN, YU. M., GUREVICH, V. L., KOZUB, V. I., Institute of Physics and Technology imeni A. F. Ioffe, USSR Academy of Sciences

[Abstract] This review discusses the theory of nonlinear acoustic phenomena in metals and semiconductors, occurring during transmission of short-wave sound, i.e., sound with a wavelength much shorter than the mean free path of conduction electrons through them. The interaction of electrons with sound in the conductors, absorption of longitudinal sound in metals, specifics of nonlinear absorption and amplification of sound in semiconductors, and nonlinear effects which appear upon propagation of sound through metals immersed in a magnetic field are discussed. Future experimental and theoretical trends are noted. In general, the discussion is limited to nonlinear phenomena caused by electrons, since the condition of sound wavelength being much less than the mean free path can only occur at very low temperatures, and at these low temperatures, conduction electrons play a decisive role in the acoustical effects observed. Figures 5; references 54: 41 Russian, 13 Western.

USSR

## RESONANT EXCITATION OF HYPERSOUND BY TWO-DIMENSIONAL PLASMONS

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 76 No 5, May 79 pp 1812-1815 manuscript received 28 Dec 78

KRASHENINNIKOV, M. A. and CHAPLIK, A. V., Institute of Physics of Semiconductors, Siberian Department, Academy of Sciences USSR

[Abstract] In previous research these authors showed that in a metal-dielectric-semiconductor structure on a piezosemiconductor, or on a thin semimetal or semiconductor film sputtered on a piezocrystal base, two-dimensional plasmons have a specific mechanism of attenuation (besides collisional and Landau damping) due to emission of sound waves into the body of the piezoelectric substrate. Thus a two-dimensional plasma wave may be a source of generation of sound on the plasmon frequency. In this paper, results are given from solution of the nonhomogeneous problem of associated plasma-acoustic oscillations, i.e., the acoustic field is found in a piezocrystal when a given external electric field is acting on its surface. The authors consider the cases of two-dimensional plasmons on the free surface of a crystal and in the inversion layer of a metal-dielectric-semiconductor structure. It is



shown how a magnetic field influences the damping of plasmons and generation of hypersound. It is shown that the plasma layer acts as a resonator, increasing the amplitude of the incident electromagnetic wave to a level sufficient for pumping the crystal lattice. The authors thank I. A. Gilinskiy for constructive criticism. Figure 1; references 6: 2 Russian, 4 Western.

USSR

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ON THE MECHANISM OF SUBSURFACE LASER FRACTURING OF TYPE CdS SEMICONDUCTORS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 1105-1108  
manuscript received 10 Aug 78

BORSHCH, A. A., BRODIN, M. S., KRUPA, N. N., TARANENKO, L. V. and CHERNYY, V. V., Institute of Physics, Academy of Sciences UkrSSR, Kiev

[Abstract] An investigation is made of the mechanisms responsible for development of body fractures in semiconductors of the CdS type under the action of laser radiation. The kinetics of development of fractures was studied by measuring the photoconductivity of CdS crystals that arises at the instant of onset of body fractures when the crystal is exposed to neodymium laser emission. The purest crystals were used in which the development of body fractures begins at the point of the geometric focus of a short-focus lens concentrating the Q-switched single-mode laser radiation on the crystal. The photocurrent pulses were registered on an oscilloscope. The studies were done at room temperature. The results are given as curves for photocurrent amplitude as a function of incident intensity. Analysis of the experimental data reveals direct carrier multiplication as body fractures arise, dependence of the threshold of body fractures on the amplitude of the field of the light wave and also zero-lag development of the fractures themselves. These results show that the mechanism of electron avalanche ionization is predominant in the development of body fractures of pure semiconductors of the CdS type exposed to nanosecond laser pulses. Figures 4; references 8: 6 Russian, 2 Western.

USSR

INFLUENCE THAT PLASTIC DEFORMATION AND IMPURITIES HAVE ON INTERNAL FRICTION IN SOLID He<sup>4</sup>

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 76 No 5, May 79 pp 1690-1699 manuscript received 20 Nov 78

TSYMBALENKO, V. L., Institute of Physical Problems, Academy of Sciences USSR, Institute of Solid State Physics, Academy of Sciences USSR

[Abstract] At present there is no model that satisfactorily describes all experimental results of measurement of internal friction in crystal helium. Internal friction due to dislocations depends on the internal state of the specimen. This state can be altered by changing the conditions of crystal growth or by plastic deformation, and in this way one could distinguish the contribution made by dislocations to internal friction. Dopants also influence the magnitude of dislocational internal friction. The author studies

the influence that these factors have on internal friction in crystals of  $\text{He}^4$  with molar volume  $V_{\text{mol}} = 20.55 \text{ cm}^3$ . The measurements are made at 15 and 78 kHz. The specimens were grown at constant pressure and also by the blocked capillary technique. A special container was used to enable measurement of attenuation as the solid helium was subjected to plastic deformation. The internal friction was also determined in specimens of solid helium doped with 0.01-0.1 at.%  $\text{He}^3$ . A number of dislocation parameters are determined by analysis of temperature and amplitude curves according to Granato-Lücke theory. The author thanks P. L. Kapitza for granting permission to do this research at the Institute of Physical Problems, A. I. Shal'nikov for continued interest, and V. I. Voronin for consultation on the experimental method. Figures 6; references 15: 9 Russian, 6 Western.

USSR

#### NATURAL OPTICAL ACTIVITY IN SEMICONDUCTORS WITH WÜRTZITE STRUCTURE

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 76 No 5, May 79 pp 1837-1855 manuscript received 12 Jan 79

IVCHENKO, YE. L. and SEL'KIN, A. V., Physicotechnical Institute imeni A. F. Ioffe, Academy of Sciences USSR

[Abstract] Theoretical and experimental studies are done on natural optical activity in the vicinity of exciton resonances of crystals of the Würtzite type ( $C_{6v}$  symmetry). Reflection spectra are calculated for parallel and crossed polarizations of the incident and reflected light. The method of calculating the reflection coefficient is generalized to the case of oblique incidence of light for the degenerate exciton level with consideration of dipole-forbidden states. An examination is made of the limiting transition to the nonresonant region, enabling comparison of the conclusions of the microscopic theory with the results of the phenomenological approach. The authors are the first to undertake an experimental study of the reflection spectra of CdS in the case of oblique incidence of light on the crystal boundary in the region of exciton resonance  $B_n=1$ . A comparison is made between the theoretical and experimental results. Agreement shows the applicability of the proposed theory to description of natural optical activity of crystals with  $C_{3v}$ ,  $C_{4v}$  and  $C_{6v}$  symmetry in the region of exciton resonance frequencies. The authors thank G. Ye. Pikus and S. A. Permogorov for volunteering to study the questions considered here, and for interest in the work, and also V. M. Agranovich for useful discussion. Figures 5; references 19: 14 Russian, 5 Western.

## INFRARED ABSORPTION OF ZINC SELENIDE CRYSTALS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 30 No 4, Apr 79 pp 707-711 manuscript received 6 Mar 78

GRAVEL', L. A., NOVIKOV, YU. B., PLECHKO, L. L., SOLNTSEV, V. M. and CHUPOV, V. D.

[Abstract] In an attempt to determine the nature of infrared absorption in zinc selenide crystals, an investigation was made of their absorption spectra in the range of 2.5-14  $\mu\text{m}$ , and of the influence that annealing of the specimens has on these spectra. The method of infrared radiative spectroscopy was used. The error of determination of absorption was 15%. All spectra showed increased absorption in the short-wave and long-wave regions, and a large number of bands. Annealing in vacuum and in a selenium atmosphere at 500-800°C leads to an increase in the intensity of bands, and also to new bands in a given specimen close to or coinciding with bands that show up in other unannealed specimens. It is shown that the observed spectra can be attributed to the formation of carbon compounds in the crystals. The bands indicate that associates are formed during crystallization with groups C-O, O=O, C-H, C-C and C=C. These associates have a composition determined by cooling conditions below the crystallization point, and may vary from one specimen to the next. The absorption indicates covalent nature of the bonds in the impurity associates in these crystals. Figures 3; references 13: 4 Russian, 9 Western.

USSR

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## AN INFRARED PLASMA PARAMETRIC AMPLIFIER

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR, SERIYA  
TEKHNICHESKIKH NAUK in Russian No 3, Issue 1, Feb 79 pp 64-70

JAMES, C. R., MILROY, R. D. and CAPJACK, C. E., Canada

[Abstract] An infrared plasma amplifier is suggested, designed according to a nonlinear theory. Its operating principle is that two infrared beams, directed oppositely to each other, interact in a magnetic plasma and produce a signal at the longitudinal difference frequency. Three possible layouts of the optical amplifier are presented. In each one, the plasma is compressed radially by means of a solenoidal magnetic field. Although some of the laser beams enter the plasma at a slight angle, this causes no problem, since the beam is directed downward along the axis of the solenoid due to the minimal density on the axis, created by the process of formation of the plasma or by a CO<sub>2</sub> laser. The two advantages of using a plasma rather than a crystal for parametric amplification are: the possibility of producing high power without limitation due to the strength of the crystal; and the absence of the condition of phase equilibrium, since the plasma wave is a controlled signal with a frequency equal to the difference frequency of the driving lasers and a propagation vector equal to the difference in the propagation vectors of the driving lasers. Figures 9; references 10 (Western).

USSR

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## POSSIBILITIES FOR MEASURING THE FARADAY EFFECT IN PULSED MAGNETIC FIELDS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 30 No 4, Apr 79 pp  
712-717 manuscript received 19 Oct 78

USHAKOV, I. I.

[Abstract] An analysis is made of methods of measuring the Faraday effect in pulsed magnetic fields of variable damped amplitude. Periodic unipolar magnetic field pulses are used to improve measurement accuracy. In this way, Faraday rotation is determined from the change in output pulse shape corresponding to half the amplitude of the angle of rotation of the polarization plane by the pulsed magnetic field as the analyzer (or polarizer) is continuously rotated, rather than from the intensity of the signal recorded by the light-sensitive receiver. Spectra of the Faraday effect in the absorption region of study specimens are measured by synchronizing unipolar magnetic field pulses with a pulsed emission source, which improves the signal-to-noise

ratio. In the case of cw operation of the radiation source and corresponding intensity of magnetic field pulses, magneto-optic pulse multiplication is observed at the output of the Faraday cell due to rotation of the polarization plane through large angles that are multiples of  $90^\circ$ . The deviation of the minima between these pulses from the zero line on oscillograms of the Faraday effect can be attributed to ellipticity that arises in strong pulsed magnetic fields. Figures 3; references 16: 13 Russian, 1 Polish, 2 Western.

USSR

THE TRANSIENT CHARACTERISTICS OF A SEMICONDUCTOR SWITCH ACTIVATED BY A LASER PULSE

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 49 No 5, May 79 pp 1013-1021 manuscript received 17 Aug 78

GREKHOV, I. V., LEVINSHCHTEIN, M. YE., SERGEYEV, V. G., YASSIYEVICH, I. N., Institute of Physics and Technology imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] A recent work studied the transient process of rise and fall of current in a circuit switched by a thyristor or reverse-biased pn junction which is activated by a laser pulse. In this work, the authors continue the study of the transient processes in switches of this type, studying current rise and fall, as well as the dynamics of the change in voltage across the switch over a broad band of laser pulse intensities. Figures 6; references 7: 5 Russian, 2 Western.

USSR

UDC 537.1

THE VIRIAL THEOREM FOR A SYSTEM OF CHARGED PARTICLES

Moscow USPEKHI FIZICHESKIKH NAUK in Russian Vol 128 No 1, May 79 pp 161-164

SHAFRANOV, V. D., Institute of Nuclear Energy imeni I. V. Kurchatov

[Abstract] A study is made of the relationship between various formulations of the virial theorem, one of the integral results of the equations of motion of a continuous medium or system of interacting particles. This theorem defines the global conditions of retention of a system in a finite area of space without analyzing the specific structure of the system. The theorem is equally applicable to large (astronomical) masses, in which retention is materially aided by the force of gravity, and much smaller masses, in which plasma retention must be aided by magnetic-field confinement. Errors noted in earlier works are corrected. References 7: 5 Russian, 2 Western.



USSR

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## CALCULATION OF ENERGY CHARACTERISTICS OF A PULSED CHEMICAL HF LASER WITH A SPHERICAL TELESCOPIC CAVITY

Moscow IVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 926-932 manuscript received 20 Jun 78

STEPANOV, A. A. and SHCHEGLOV, V. A., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] The energy characteristics of a pulsed chemical HF laser with spherical telescopic cavity are calculated in the geometric optics approximation. It is assumed that the time of establishment of the modal structure in the cavity is shorter than the characteristic duration of a lasing pulse. In calculating conditions of stimulated emission, the authors use the quasi-steady state approach that corresponds to the usual requirement for pumping rate. Within the framework of the initial approximations, the problem, which is unsteady in the general case, is reduced to solution of a simpler three-dimensional steady-state problem at each fixed instant. The results are compared with the case of a cavity with flat mirrors. An investigation is made of conditions of stimulated emission of short pulses with photo-initiation. It is shown that telescopic cavities with magnification of 10-100 should be used in such lasers to minimize the width of the radiation pattern. Figures 5; references 14: 12 Russian, 2 Western.

USSR

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## A THEORETICAL STUDY OF THE ENERGY AND SPECTRAL CHARACTERISTICS OF A LASER UTILIZING THE SECOND HARMONIC OF THE CARBON MONOXIDE MOLECULE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 960-964 manuscript received 5 Jul 78

SUCHKOV, A. F. and SHEBEKO, YU. N., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] The energy and spectral characteristics of an electron beam-controlled laser on the second harmonic of the carbon monoxide molecule are studied by numerical integration of the system of rate equations that account for stimulated emission on the P-branch of vibrational-rotational transitions with  $\Delta V = 2$ , and by varying the populations of vibrational levels and translational temperature as a result of VV-, VT- and eV exchanges. It is assumed that there is no lasing on the fundamental vibrational mode of the CO molecule.

The calculations are done for pure carbon monoxide and for a CO-N<sub>2</sub> mixture. The analysis is based on up-to-date information regarding the processes involved. It is found that there is an alternation of the intensities of lines in the laser spectrum that can be attributed to the high specific pumping energy that goes to the carbon monoxide in the CO-N<sub>2</sub> mixture. An investigation is made of the influence of nitrogen on output parameters of the laser for high values of the concentration ratio  $\beta = [N_2]/[CO]$ . It is shown that efficiency is independent of the pumping distribution with respect to the components, and does not depend on  $\beta$ . The authors thank B. M. Urin for useful discussion of the results, and also V. I. Dolinina and V. D. Kozlov for assistance with the computer calculations. Figures 5; references 16: 8 Russian, 8 Western.

USSR

UDC 373.826

# A LASER ON A MIXTURE OF Ar-Xe-NF<sub>3</sub> WITH DISCHARGE STABILIZED BY A SHORT-PULSE ELECTRON BEAM

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 1004-1009  
manuscript received 15 Jul 78

BYCHKOV, YU. I., KONOVALOV, I. N. and TARASENKO, V. F., Institute of Physics of the Atmosphere, Siberian Department, Academy of Sciences USSR, Tomsk

[Abstract] An examination is made of conditions of excitation of an excimer laser in the case of a 50 ns discharge-stabilizing electron beam. Electron energy was 100-200 keV, and the current density of the beam was 25 A/cm<sup>2</sup>. The beam was coupled into the discharge gap from the accelerator through a slot measuring 2.6 x 20 cm covered with steel foil 25  $\mu$ m thick. It is shown that with proper selection of the inductance of the discharge loop and shape of the electron beam pulse, maximum discharge power of 10<sup>6</sup> W/cm<sup>3</sup> or more is reached during reduction of the beam current. A high-power pumping pulse is formed with high voltage across the plasma (of the order of the charging voltage). This mode is suitable for producing emission pulses of short duration. It is typical of the investigated pumping mode that the voltage across the plasma is considerably higher than under steady-state conditions when the discharge is stabilized by an electron beam of long duration. Thus the voltage across the plasma can be made suitable for maximum XeF laser efficiency. Studies of the energy characteristics of the excimer laser showed that specific emission energies of 2.5 joules per liter can be achieved with pulse duration at half-height of 20 ns and emission power of 6.2 MW when the pressure of the working mixture is 4 atm and the initial electric field strength is 25 kV/cm. Figures 5; references 9: 3 Russian, 6 Western.

## KINETICS OF FORMATION OF EXCIMERS IN LASERS BASED ON MIXTURES OF INERT GASES WITH FLUORINE

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 1010-1018  
manuscript received 20 Jul 78

BASOV, N. G., DANILYCHEV, V. A., DOLGIKH, V. A., KERIMOV, O. M., LEBEDEV, V. S. and MOLCHANOV, A. G., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR

[Abstract] In electron-beam excitation of mixtures of inert gases with fluorine, excimers  $\text{ArF}^*$ ,  $\text{KrF}^*$  and  $\text{XeF}^*$  are produced with band centers 193, 248 and 354 nm that are now extensively used for intense emission in the ultraviolet band. Recent research has demonstrated the existence of a new class of excimers  $\text{R}_2\text{X}$  and  $\text{RR}'\text{X}$ , where R and R' are atoms of inert gas and X is a halide atom. The emission bands of these triatomic excimers are strongly shifted toward the long-wave side relative to the emission bands of diatomic excimers  $\text{RX}^*$ . The authors study the emission spectra and kinetics of formation of excimers  $\text{RX}^*$ ,  $\text{R}_2\text{X}^*$  and  $\text{RR}'\text{X}^*$  in gas mixtures of Ar- $\text{F}_2$ , Ar-Kr- $\text{F}_2$  and Kr-Xe- $\text{F}_2$  stimulated by an electron beam over a wide range of pressures (0.2-20 atm) and temperatures (150-500 K). It is shown that as the temperature and pressure vary over these ranges, considerable changes take place in the energy distribution among diatomic and triatomic excimers. This explains the experimentally observed abrupt increase in the intensity of spontaneous and stimulated emission of the 248 nm band in a mixture of Ar-Kr- $\text{F}_2$  when there is an increase in gas temperature. The reduced efficiency of existing inert-halide lasers at high pressures can also be attributed to this effect. The optimum temperature where laser emission is maximized on 248 nm is in the vicinity of 400 K. Figures 8; references 15: 3 Russian, 12 Western.

USSR

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# OPTIMIZING A GASDYNAMIC LASER CAVITY

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 1019-1025  
manuscript received 20 Jul 78

BAKANOV, D. G., ODINTSOV, A. I., FEDOSEYEV, A. I. and SHARKOV, V. F., Moscow State University imeni M. V. Lomonosov

[Abstract] A simplified gasdynamic laser model is proposed for solving the problem of laser cavity optimization. The analysis reveals physical patterns of nonlinear saturation in gasdynamic lasers that frequently go unnoticed in numerical calculations. The calculations are based on a three-level laser model that gives a fairly satisfactory description of the properties of real gasdynamic lasers based on a  $\text{CO}_2\text{-N}_2$  mixture with additives of  $\text{H}_2\text{O}$  and He to accelerate the relaxation of the lower laser level. The following assumptions are made: 1. gasdynamic characteristics of the flow, including gas temperature, remain constant within the limits of the cavity zone; 2. the population of the lower laser level is in equilibrium with the gas temperature; 3. molecular nitrogen loses vibrational energy only via VV-exchange with carbon dioxide molecules; 4. the field within the cavity is described by a plane homogeneous wave. The paper gives data on saturation of the active medium, analytical relations and graphs that can be used to determine the optimum parameters of a gasdynamic laser cavity. Experimental results show satisfactory agreement with the theory. The authors thank A. N. Baranov for taking part in the experiments. Figures 4; references 11: 9 Russian, 2 Western.

USSR

UDC 621.315.592

# ON THE THEORY OF DEFECT-FORMING RESONANT ELECTRON CAPTURE IN LASER CRYSTALS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 1057-1061  
manuscript received 12 Sep 78

YELISEYEV, P. G., ZAVESTOVSKAYA, I. N., POLUEKTOV, I. A. and POPOV, YU. M., Physics Institute imeni P. N. Lebedev, Moscow

[Abstract] Under conditions of intense electron-hole recombination in laser crystals, there is a theoretical probability on an elementary act of defect formation due to resonant capture of an electron on a deep level. It has been demonstrated that there is a finite probability of release of the energy liberated during capture in the form of kinetic energy of an atom. An important parameter of a mechanism of this kind is the width of the self-ionization of the resonance level. In this paper the authors calculate this

parameter by using refined wave functions of the deep level, and make a numerical analysis of the way that this parameter depends on the energy of the captured electron and various parameters of the capture center, as well as considering some problems of the kinetics of defect formation and comparing the results with some experimental data. The cases of acceptor and donor centers are considered. Functions are derived that describe the growth in lasing threshold and service life of a laser. The authors thank V. S. Karakhtanov for assistance with the numerical computer calculations. Figure 1; references 10: 8 Russian, 2 Western.

USSR

UDC 621.373.8.038.82

ON THE FEASIBILITY OF ACHIEVING EFFICIENT CONTINUOUS STIMULATED EMISSION IN OPTICALLY PUMPED LASERS USING SELF-LIMITING TRANSITIONS

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manuscript received 9 Aug 78

BATENIN, V. M., GOLGER, A. L. and KLIMOVSKIY, I. I., Institute of High Temperatures, Academy of Sciences USSR, Moscow

[Abstract] An investigation is made of the feasibility of getting cw lasing on self-limiting transitions with optical pumping of resonant levels of the working gas where depopulation of metastable levels of the working gas by conventional techniques is not disrupted by the presence of an electric discharge. The pumping efficiency of such a laser system is shown to be close to the quantum efficiency, and may reach 50%. When the pumping emission power density is of the order of  $0.3 \text{ W/cm}^2$ , a gain of more than  $10^{-3} \text{ cm}^{-1}$  can be realized with laser output power of the order of 100 W per meter of active medium. Figure 1; references 12: 8 Russian, 4 Western.



USSR

UDC 621.373.826.038.823

PULSED LASING ON ELECTRON TRANSITIONS OF THE  $I_2$  MOLECULE WITH OPTICAL PUMPING BY A COPPER-VAPOR LASER

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 1086-1087  
manuscript received 10 Dec 78

KASLIN, V. M., PETRASH, G. G. and YAKUSHEV, O. F., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] Experiments were done on pulsed stimulated emission on new transitions of the system  $B^3\Pi_u-X^1\Sigma_g^+$  of the  $I_2$  molecule with optical pumping by a copper-vapor laser. Lasing was observed with a pulse recurrence rate of 7 kHz on two lines (510.6 and 578.2 nm) with ratio of average powers depending on the conditions of laser operation, and usually amounting to 3:1 in these experiments. The copper laser emission was focused by a quartz lens with focal length of 1 m into a cell 26.5 cm long containing the iodine. The cell was enclosed in a cavity formed by two flat multilayer dielectric reflectors with  $R=97\%$  in the region of the emission maximum (1.2  $\mu$ m). The pumping beam was 4 mm in diameter. Excitation of iodine molecules was observed in five channels. The most effective of these were transitions to levels ( $v' = 14$ ,  $J' = 52$ ) and ( $v' = 16$ ,  $J' = 30$ ) of the B state with pumping by the yellow line on 578.2 nm. The spectrum of molecular stimulated emission was made up of characteristic doublets in the region of 1.016-1.34  $\mu$ m. With energy conversion efficiency of 1%, the overall peak lasing power was 30 W. References 6 (Russian).

USSR

UDC 621.375.826

MODE SELECTION IN RING-CAVITY DYE LASERS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 1090-1092  
manuscript received 4 Nov 78

KÜHLKE, D., SCHRÖTER, S. and DIETEL, W., Schiller University, Jena, East Germany

[Abstract] In ring lasers, stimulated emission in two directions predominates over unidirectional lasing because of wave scattering by the cavity components. There are two ways to get lasing in one direction: 1. If frequency-dispersion elements are used to isolate one mode from the multimode spectrum of a ring laser with opposed waves, this mode will propagate in one direction. One of the possible two bistable directions is selected by

reflecting the output back into the cavity. 2. If optical anisotropy is set up in the ring cavity to make the intensity ratio of the opposed waves much greater than unity, stable single-mode lasing can be achieved even with dispersion elements with relatively low selectivity. In this paper experimental results using the second method are given and compared with the first method. It is shown that a ring dye laser can be used to get a high ratio of powers in the single-mode and multimode states with cw operation. Optical anisotropy is introduced by using a Faraday element and optically active quartz. To get lasing in one direction, a loss difference must be set up between the opposed directions that exceeds the backscattering of laser radiation by the cavity components. In the case of a carefully made cavity, this condition is met when the polarization plane is turned through a few degrees by using a material with a low Verdet constant. Figures 2; references 6 (Western).

USSR

UDC 535.89

# ARC DISCHARGES IN ALKALI METAL VAPORS AS POSSIBLE SOURCES FOR PUMPING YAG:Nd<sup>3+</sup> LASERS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 30 No 4, Apr 79 pp 628-632 manuscript received 14 Mar 78

ANAN'YEV, A. YU., DAVYDOV, S. F., KOLPAKOVA, I. V., MAK, A. A. and YAKOVLEV, S. A.

[Abstract] Previous research has shown that potassium lamps can be used for effective pumping of YAG:Nd<sup>3+</sup> lasers at electric powers up to 500-600 W. The authors measure the spectral distribution of emission power of arc lamps with alkali metal vapors and determine the conditions that maximize the efficiency of radiation of such lamps in spectral intervals that coincide with the absorption bands of neodymium and garnet, comparing this efficiency with that of krypton arc lamps of the same dimensions. The radiation efficiency in this context is defined as the ratio of the power emitted by the lamp in the given spectral range to the electric power supplied to the lamp. The lamps investigated are sapphire tubes containing vapors of K, K + Rb and Na + K. It is shown that with proper selection of vapor pressure, the radiation efficiency of these lamps in the absorption bands of interest considerably exceeds that of krypton arc lamps with similar dimensions of the discharge gap at electrical powers up to 1 kW. Figures 4; references 15: 4 Russian, 11 Western.



USSR

UDC 621.375.82

INFLUENCE THAT INTRACAVITY ABSORPTION HAS ON THE CHARACTERISTICS OF A MODE-LOCKED DYE LASER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 30 No 4, Apr 79 pp 633-638 manuscript received 21 Mar 78

BELOKON', M. V., ADAMUSHKO, A. V. and RUBINOV, A. N.

[Abstract] Pulsed dye lasers pumped by lasers and flash tubes, and also cw lasers are currently being used in intracavity spectroscopy. The authors give experimental results on the influence that intracavity selective absorption has on the characteristics of a mode-locked dye laser. This kind of laser is of interest because of the feasibility of changing the sensitivity of intracavity measurements by altering the degree of mode locking, as well as from the standpoint of developing stroboscopic absorption spectrometers with improved sensitivity and time resolution. The experiments were done on a laser using a Rhodamine G solution in ethylene glycol with mode-locked argon laser pumping. An investigation is made of variations of spectral characteristics and sensitivity of intracavity detection of small absorptions for different modes of excitation. Close to lines of absorption from ls levels of neon, the authors observe capture, stabilization of position and narrowing of the band of locked modes. It is shown that one possible mechanism leading to self-mode locking is diffraction by the light-induced lattice of the index of refraction of the substance in the dye laser cavity. Figures 3; references 11: 7 Russian, 4 Western.

USSR

UDC 621.375.9

NARROWING OF THE EMISSION SPECTRUM IN LASERS WITH ELECTRO-OPTICAL SHUTTER

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 30 No 4, Apr 79 pp 639-646 manuscript received 31 Oct 77

KO/ALEV, A. A., KABAYEV, N. I., TYUSHKEVICH, B. N. and YUREVICH, V. A.

[Abstract] The paper gives the results of a theoretical and experimental study of the mechanism of narrowing of the emission spectrum and single-frequency monopulse emission in a ruby laser with an electro-optical shutter due to narrow-band free lasing primer radiation in the cavity. An investigation is made of the influence that this primer radiation has on mode competition under giant pulse lasing conditions. The theoretical results show that rf modulation of the gain makes mode competition dependent on the

initial conditions even in the case of equal losses. In particular, a difference in the radiation densities of individual modes leads to suppression of the mode with lower initial density. In the experiments, the advantage in initial density is given to one of the axial modes of the giant pulse by narrow-band primer radiation formed in a supplementary cavity before Q-switching. Monopulse lasing is achieved with spectral width of less than 100 MHz and energy up to 0.2 J. Increasing the lasing energy to about 0.6 J broadens the spectrum to about 300 MHz. Figures 3; references 19: 13 Russian, 6 Western.

USSR

UDC 621.378.325

#### CHANGES IN THE VIBRATIONAL TEMPERATURE OF NITROGEN IN FAST-FLOW CO<sub>2</sub> LASERS

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 49 No 5, May 79 pp 970-974 manuscript received 18 Apr 78; in final form 25 Sep 78

BLOKHIN, V. I., MYSLIN, V. A. and PASHKIN, V. S.

[Abstract] In order to determine the mechanisms which determine the efficiency of fast-flow molecular CO<sub>2</sub> lasers, one must measure the vibrational temperature of the ground state of the nitrogen molecule. In a gas-discharge chamber, this can be done by a method based on determination of the vibrational temperature of the ground electron state by measurements of the relative populations of vibrational levels of the electron state. This article presents some corrections to the calculation equations used in this method, so that it can be applied at pressures above 10 mm Hg. Figures 4; references 18: 10 Russian, 8 Western.

USSR

UDC 533.9.08

SOME NEW POSSIBILITIES FOR DIAGNOSIS OF SINGLE-PHASE AND TWO-PHASE PLASMA JETS

Novosibirsk IZVESTIYA SIBIRSKOGO OTDELENIYA AKADEMII NAUK SSSR, SERIYA TEKHNICHESKIKH NAUK in Russian No 3, Issue 1, Feb 79 pp 80-95 manuscript received 16 Jun 78

GOL'DFARB, V. M., Leningrad State Pedagogic Institute imeni A. I. Gertsen

[Abstract] A review is presented of the trends in the development of methods of diagnosis of plasma jets over recent years. Methods mentioned include spectroscopic measurements, measurements of refraction, measurements of scattering, measurements of plasma velocity, electrostatic probing, calorimetric probing, pyrometry, production of images of particles of tracks, diffraction, measurement of attenuation of light and laser Doppler measurements. Each method is briefly described, and a table sets forth several varieties of each method. Figures 4; references 218: 65 Russian, 153 Western.

USSR

UDC 532.526.2:538.4

THEORY OF A LAMINAR BOUNDARY LAYER OF A CONDUCTING NON-NEWTONIAN FLUID WITH A POWER-LAW RHEOLOGICAL CHARACTERISTIC IN A TRANSVERSE MAGNETIC FIELD

Riga MAGNITNAYA GIDRODINAMIKA in Russian No 1, Jan/Mar 79 pp 33-38 manuscript received 10 Apr 78

PAVLOV, K. B.

[Abstract] A conducting nonlinearly viscous fluid having a power-law rheological characteristic is considered with a laminar MHD boundary layer in a magnetic field transverse to and an electric field normal to the direction of flow. The corresponding two-dimensional Navier-Stokes equation for such a boundary layer, assuming a zero transverse pressure gradient and a zero divergence of the velocity vector, is treated in the zero-(induced) current approximation and transformed to a third-order differential equation in an appropriately chosen self-adjoint variable. The solution is analyzed for dilatant fluids ( $n > 1$ ), where it is proved here rigorously that spatial localization of changes in the longitudinal velocity always occurs. No spatial localization of this kind occurs in pseudoplastic fluids ( $1 > n > 1/2$ ). A physical interpretation of this is given in terms of propagation of shear perturbations. The results are extended to a conducting dilatant fluid flowing at a constant velocity in constant magnetic and electric fields around

an impermeable semi-infinitely large flat plate, in which case a unique "saturation" of a spatially localized MHD boundary layer is found to occur. References 10: 9 Russian, 1 Western.

USSR

PARAMETRIC GENERATION OF MAGNETIC FIELDS WHEN HIGH-INTENSITY RADIATION ACTS ON A PLASMA

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 76 No 5, May 79 pp 1586-1592 manuscript received 4 Dec 78

ALIYEV, YU. M. and BYCHENKOV, V. YU., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR

[Abstract] It was shown in previous research that a field can be generated in a plasma when a magnetic instability develops that is initiated by high-frequency pumping radiation [see A. Sh. Abdullayev, Yu. M. Aliyev, V. Yu. Bychenkov, "Pis'ma v zhurnal eksperimental'noy i teoreticheskoy fiziki," Vol 28, 1978 p 524]. The analysis was done in the strongly collisional hydrodynamics approximation under conditions where the mean free path of electrons is shorter than the perturbing wavelength, and the time of collisions is less than the characteristic time of change of the fields. Now the authors develop these concepts further. A kinetic description is given of parametric generation of the fundamental harmonic of a nonpotential field of perturbations. An analysis is made of the linear stage of instability over a wide range of wavelengths and frequencies. An estimate is given for the nonlinear level of saturation of the magnetic field. The results show that the proposed mechanism can be used to generate magnetic fields on the megagauss level in a laser plasma. The authors thank L. M. Gorbunov and V. P. Silin for interest in the work and constructive criticism. References 14: 9 Russian, 5 Western.

## PHENOMENA NEAR THE ELECTRODE IN A LOW-TEMPERATURE PLASMA (A REVIEW)

Leningrad ZHURNAL TEKHNICHESKOY FIZIKI in Russian Vol 49 No 5, May 79 pp 905-944 manuscript received 26 Sep 78; in final version 30 Nov 78

BAKSHT, F. G., YUR'YEV, V. G., Institute of Physics and Technology imeni A. F. Ioffe, USSR Academy of Sciences, Leningrad

[Abstract] This review presents an analysis of the specifics related to the distribution of potential and concentration, transmission of current, maxwellization of electrons and formation of ions in the near-electrode space in a low-temperature plasma such as those used in MHD generators, plasma chemistry and electric-arc devices. The analysis is presented from a rather general standpoint, independent of the method of generation of the plasma. Of the surface phenomena, only the emission characteristics of the electrodes are studied, to the extent that they are determined by the properties of the plasma near the electrode. The study is confined to rather dense plasmas under conditions such that far from the electrode, a near-equilibrium state is created, either for the entire plasma, or for the electrons and the heavy components individually. The near-electrode space thus refers to the area between the equilibrium plasma and the surface of the electrode. Figures 29; references 151: 121 Russian, 30 Western.

USSR

UDC 621.378.33

## PARTICULARS OF ABSORPTION OF INTENSE INFRARED RADIATION BY MOLECULES (SURVEY)

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 885-901  
manuscript received 12 Sep 78

GALOCHKIN, V. T. and ORAYEVSKIY, A. N., Physics Institute imeni P. N. Lebedev,  
Academy of Sciences USSR, Moscow

[Abstract] The literature is reviewed on problems of molecular excitation to high levels by the resonant action of laser emission on vibrational degrees of freedom of molecules. It is shown that very high intensity of stimulating radiation is required to overcome the anharmonicity of molecular vibrations due to Stark broadening. The part played by the rotational structure of molecules in compensating this anharmonicity is discussed, and it is shown how pulse duration and intensity influence compensation of anharmonicity by rotation. The part played by processes of higher order and other effects is discussed, and experimental data are given on the relaxation times and molecular constants for sulfur hexafluoride and boron trichloride. It is shown that the red shift of the frequency corresponding to maximum absorption of intense infrared radiation must be considered when looking for windows of transparency in various gases. More research is needed on many-photon excitation of molecules by intense infrared radiation. Figures 13; references 51: 36 Russian, 15 Western.

USSR

UDC 66.092

SEPARATION OF ISOTOPES BY THE METHOD OF MANY-PHOTON DISSOCIATION OF MOLECULES USING POWERFUL CO<sub>2</sub> LASER RADIATION. IV. ENRICHMENT OF THE ISOTOPE <sup>33</sup>S WITH TREATMENT OF COOLED SF<sub>6</sub> GAS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 1062-1069  
manuscript received 23 Jan 78

BARANOV, V. YU., VELIKHOV, YE. P., KOLOMIYSKIY, YU. R., LETOKHOV, V. S.,  
NIZ'YEV, V. G., PIS'MENNYI, V. D. and RYABOV, YE. A., Institute of Spectroscopy,  
Academy of Sciences USSR, Moscow, Institute of Atomic Energy imeni  
I. V. Kurchatov, Moscow

[Abstract] This paper is one of a series dealing with an investigation of the process of laser separation of isotopes by the method of many-photon dissociation of molecules. The feasibility of realizing such a process on a practical scale has already been demonstrated in experiments with the SF<sub>6</sub> molecule, oriented toward enrichment of isotope <sup>34</sup>S. In this paper a study is done on the feasibility of achieving high parameters of the separation



process, and in particular high selectivity, by dissociating molecules with the target isotope as the gas is cooled, which leads to considerable narrowing of the spectrum of many-photon absorption of  $\text{SF}_6$ . The studies are done on  $\text{SF}_6$  with the natural concentration of  $^{33}\text{S}$  (0.76%). The temperature range was 123-293 K. The optimum temperature for dissociation of  $^{33}\text{SF}_6$  was found to be 170-190 K where the dissociation yield is not reduced much below its room-temperature value, and at the same time the degree of separation in the products  $q(33/32)$  reaches a value of 4.5-5 with consumption of  $^{33}\text{SF}_6$  of about 60%. The results show the practical feasibility of enrichment of  $^{33}\text{S}$  in industrial amounts. In conclusion the authors thank A. S. Akhmanov and V. N. Bagratshvili for assisting with the measurements. Figures 6; references 13: 7 Russian, 6 Western.

USSR

UDC 621.375.826

STIMULATED EMISSION ON THE BOUND-FREE TRANSITION  $C(3/2)-A(3/2)$  OF THE  $\text{XeF}$  MOLECULE WITH PHOTODISSOCIATION OF  $\text{XeF}_2$

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 p 1074 manuscript received 28 Feb 79

BASOV, N. G., ZUYEV, V. S., KANAYEV, A. V., MIKHEYEV, L. D. and STAVROVSKIY, D. B., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] In previous research, laser emission was observed on the transition  $B(1/2)-X(1/2)$  of the  $\text{XeF}$  molecule produced when  $\text{XeF}_2$  undergoes photodissociation under the action of vacuum ultraviolet radiation of an open high-current discharge. In this paper, the same kind of pumping is used to get lasing on the bound-free transition  $C(3/2)-A(3/2)$  in the wavelength region of 455-495 nm. This laser emission was observed with stimulation of the gas mixtures  $\text{XeF}_2:\text{N}_2:\text{Ar} = 2:160:1000$  mm Hg and  $\text{XeF}_2:\text{N}_2 = 2:460$  mm Hg. The cavity was 1 m long and 1 cm in diameter, and pumping was by a discharge 70 cm long. The energy of stimulated emission reached 4 mJ with duration of 1.5  $\mu\text{s}$ . The width of the lasing spectrum was about 40 nm in the region of maximum Q of the cavity. Excited molecules of  $\text{XeF}(C)$  are produced by photolysis of  $\text{XeF}_2$ , leading to the formation of  $\text{XeF}(B)$  and subsequent collisional relaxation to the C-state. The spectral range of laser tuning is about 100 nm. References 3: 1 Russian, 2 Western.



USSR

UDC 671.08:621.373.826

ALL-UNION CONFERENCE ON HIGH-SPEED PROCESSES OF LUMINOUS ENERGY CONVERSION  
IN PHOTOSYNTHESIS (MOSCOW, 19-22 SEPTEMBER 1978)

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 1114-1119

PASHCHENKO, V. Z., RUBIN, L. B. and SEMENOV, A. S.

[Abstract] An All-Union Conference on High-Speed Processes of Luminous Energy Conversion in Photosynthesis was held from 19 through 22 September 1978 by the Biology Department at Moscow State University. The conference was organized by the Inter-Faculty Committee on Problems of Biophotonics of Moscow State University, the Moscow Society of Investigators of Nature and the Chair of Biophysics of the Biological Faculty of Moscow State University. The conference was attended by more than 200 specialists on various problems of the primary conversion of energy in photosynthesis, photosynthetic electron transport, theoretical aspects of electron transport and the use of lasers in biological research. Among the delegates were 9 guests from outside the Soviet Union (5 from socialist nations). There were 30 reports, 6 of them by non-Soviet specialists. The principal topics were migration of excited states in photosynthetic membranes, mechanisms of electron transport in the primary event of photosynthesis, prospects for using laser techniques in photobiological research, and theoretical aspects of the mechanisms of electron transport in primary processes of photosynthesis.

USSR

UDC 535.37

INFRARED FLUORESCENCE EMISSION OF MOLECULAR GASES

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 30 No 4, Apr 79 pp 662-666 manuscript received 6 Mar 78

LIPOVSKIY, I. M., SVERDLOV, L. M. and FINKEL', A. G.

[Abstract] Infrared fluorescence spectra were studied in ten molecular gases in the pressure range of 5-150 mm Hg at laser radiation intensities of 4-40 W/cm<sup>2</sup>. The gases studied were n-pentane, cyclohexane, methylene bromide, methylene chloride, methyl iodide, trichloroethylene, acetone, acrolein, nitromethane and acetonitrile. Fluorescence was stimulated by a type LG-22 CO<sub>2</sub>-laser with power of about 40 W/cm<sup>2</sup> in the cw mode of operation. The integral intensities of radiation of the bands of the investigated gases were studied as a function of gas pressure and laser emission power. These relations were found to be linear for most of the gases. A table is given showing the relative intensities of fluorescence of vibrational bands and the

vibrational temperatures of the molecular gases studied. For individual bands of a number of substances (acetyl chloride,  $\nu_6 + \nu_{15}$ ,  $2180\text{ cm}^{-1}$ , trichloroethylene  $\nu_2 + \nu_{12}$   $1815\text{ cm}^{-1}$ , acrolein,  $\nu_4$ ,  $2800\text{ cm}^{-1}$ ) that are approximate multiples of the laser frequency, the integral intensities of radiation show nonlinear dependence on gas pressure and laser power. Calculation of the vibrational temperature showed deviation from Boltzmann distribution for these vibrational levels. This is attributed to two-photon absorption. Figure 1; references 13: 10 Russian, 3 Western.

USSR

UDC 621.039.534.63

## PROBLEMS OF SAFETY IN SODIUM-WATER STEAM GENERATORS AND THEIR SOLUTION IN THE USSR

Moscow ATOMNAYA ENERGIYA in Russian Vol 46 No 5, May 79 pp 311-316 manuscript received 17 Apr 78

POPLAVSKIY, V. M., BAGDASAROV, YU. E., KOZLOV, F. A., KOCHETKOV, L. A. and TITOV, V. F.

[Abstract] Sodium-water steam generators are among the most important components of atomic electric power plants operating with fast reactors such as BOR-60, BN-350 and BN-600 plants in the USSR. The concept of separating the two media by a single wall has been introduced to make the design more economical, but this concept has also created a complex of problems regarding safety. Toward their solution, an experimental study had been undertaken and theoretical method of analysis developed to deal with emergency situations in such plants. As a result, the causes of large water and sodium leakage were discovered, temperature and pressure variations within the reaction zone were determined, and protective measures had been devised by the late sixties. At the present time in the design of new equipment one needs to consider only the reaction which produces sodium hydroxide and hydrogen, this reaction assumed to occur instantaneously. Furthermore, the maximum possible pressure ( $9 \cdot 10^5 - 2 \cdot 10^6$  Pa) and temperature are assumed at the beginning of the reaction, under adiabatic conditions, and their distributions to continue to be uniform over the volume of reaction products thereafter. Any heat transfer from the interaction zone to the ambient medium is disregarded. The effect of the leakage rate on corrosive and erosive wear of various structural steels has been established, high-nickel steel found to be most resistant, also a significant decrease in spontaneous leakage with lower temperature of penetrating sodium has been noted. Small leakage was found to be destructive to the wall material only in the case of local jet formation. Experimental data are evaluated either assuming that the leakage rate increases with time and that the wall defectiveness increases with an increasing leakage rate, or assuming that the leakage rate remains constant throughout the process of destruction. While the earlier BOR-60 and BN-350 steam generators have an integral construction, the latest BN-600 steam generators have a sectional construction. Here protection is provided by immediate selective response to a leakage indicating signal, isolation and subsequent shutdown of the leaky section, prevention of pressure rises, and timely complete drainage of the coolant together with the reaction products from the leaky section on both sodium and water sides, this section then to be refilled with an inert medium. For indication of small leakage, which can develop into a large one, highly sensitive devices are now being developed in the USSR combining diffusion membranes with magnetic pumps or using acoustic probes. Large leakage is indicated by pressure changes or changes in the sodium flow rate. Membranes with forced or spontaneous rupture mechanisms are used for preventative protection. Special accessories are used for drying the water-steam loop, and high-speed devices for drying the sodium-vapor loop are being developed. References 12: 11 Russian, 1 Western.

## ACCURACY OF REGULATING THE NEUTRON FIELD IN A NUCLEAR REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 46 No 5, May 79 pp 316-319 manuscript received 23 Nov 77

PLEKHANOV, L. P.

[Abstract] Regulating the neutron field in a nuclear reactor more accurately contributes to a more economical operation of the latter. This can be achieved with an array of probes and regulating devices, but the accuracy of regulation will still depend on the number and the spacing of those as well as on their errors and other performance characteristics. Here the problem of static accuracy of regulation is treated as a linear homogeneous boundary-value problem with internal feedback with respect to the deviation of the neutron field from its nominal steady-state distribution. The problem is assumed to have no nontrivial solution, which corresponds to most reactors operating in the power mode, and the regulation error is defined in terms of a Green's function series and integral. A nonzero determinant of the transmission matrix of the object multiplied by the matrix of weighting factors of the regulators is found to be a necessary condition governing the design of the regulator system. Accordingly, first a regulator structure is shown which does not ensure unique positioning of the devices and then two improved structures are shown with integral or zonal regulation respectively. An error analysis of both indicates that zonal regulation of the neutron field is more accurate. Figures 4; references 6 (Russian).

## A LINEAR ELECTRON ACCELERATOR WITH A MEAN-CURRENT RATING OF 1 mA

Moscow ATOMNAYA ENERGIYA in Russian Vol 46 No 5, May 79 pp 336-340 manuscript received 22 Mar 78

FURSOV, G. L., GRIZHKO, V. M., GRISHAYEV, I. A., SAFRONOV, B. G., MYAKUSHKO, I. K., BALAGURA, V. S., BELOGLAZOV, V. I., GOROKHOVATSKIY, F. S., MARTYNOV, A. I. and RUDENKO, A. P.

[Abstract] A medium-energy linear electron accelerator for industrial flaw detection or for sterilization of medical and agricultural products has been developed at the Chemico-Physical Technological Institute (Academy of Sciences of the Ukrainian SSR) which operates with 1 mA (mean) current pulses of up to 10  $\mu$ s duration. The source of electrons is a 2-electrode gun with a cathode

which is heated by electron bombardment from an auxiliary gun. The current is regulated by a variable collimator and the beam is focused by two lenses with a Faraday cylinder between them. The injection voltage is 80 kV, with the injector inside a solenoid which produces a longitudinal magnetic field of 1000 Oe intensity. High-frequency power up to 10 MW is supplied to the injector and to the accelerator from separate klystrons. The equipment includes means for alignment, vacuumization, synchronization and stabilization. The accelerated electron beam passes through magnetic spectrometers and an emittance meter with appropriately placed Faraday cylinders, then through a scatterer and a titanium foil into an absorber. The device has been tested and evaluated. The energy can be continuously varied from 3.4 MeV under a maximum current load without high-frequency power in the accelerator to 40 MeV with a light load current and high acceleration. The maximum electron efficiency of both accelerator and injector is 83%, the maximum power is 16 kW at a 20 MeV energy and 0.8 mA current. The half-width of the energy spectrum in the beam increases from 1 to 4.2% with higher current. The experimental data on energy losses in the accelerator compare with calculations for an irised waveguide. Figures 4; tables 1; references 9 (Russian).

USSR

UDC 539.122:539.166.3

#### COEFFICIENT OF GAMMA-RAY SELF-ABSORPTION IN REACTOR FUEL ASSEMBLIES

Moscow ATOMNAYA ENERGIYA in Russian Vol 46 No 5, May 79 pp 344-346 manuscript received 30 Jan 78

VORONINA, V. A., KAZACHENKOV, YU. N. and SIMONOV, V. D.

[Abstract] Gamma-ray spectrometry of the fission products is a well known method of determining the isotopic composition of a nuclear fuel. In addition to measuring the intensity of gamma radiation from the products, however, it is also necessary to know the coefficient of self-absorption in the fuel assembly. Here an expression for this coefficient is derived from the general integral relation pertaining to cylindrical fuel elements and extended to the hexagonal assembly of half-ring fuel elements in a water-moderated water-cooled 440 MW power reactor, taking into account the detector location. The theoretical angular indicatrix of this coefficient is shown and numerical values are given corresponding to gamma-ray sources with various energy distributions. Figures 1; tables 2; references 4: 2 Russian, 1 German, 1 Western.



USSR

UDC 621.039.512.45

A METHOD OF MINIMIZING THE NONUNIFORMITY OF ENERGY DISTRIBUTION IN A NUCLEAR REACTOR

Moscow ATOMNAYA ENERGIYA in Russian Vol 46 No 5, May 79 pp 357-359 manuscript received 4 Jun 78

POBEDIN, V. V. and SIMONOV, V. D.

[Abstract] One aspect of controlling the nuclear fuel in a reactor internally is minimization of the nonuniformity of energy distribution over the core. Here the problem is treated as a nonlinear optimization in integers of several sets of neutron-physical characteristics. These characteristics are averaged for the first step of the optimization process and the cartogram obtained as a result is split into two zones with retention of the layout symmetry. For the second step, the initial slag field is replaced with a regular grid. All possible ways of averaging the characteristics produce the same result in the second step. Figures 2; references 7: 3 Russian, 4 Western.

USSR

UDC 621.378:533.924

MEASURING THE PARAMETERS OF SHELL TARGETS FOR LASER-DRIVEN FUSION BY AN X-RAY SCHLIEREN METHOD

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 1037-1042 manuscript received 28 Jul 78

GOETZ, K., FOERSTER, E., ZAUMSEIL, P., Schiller University at Jena, East Germany, KALASHNIKOV, M. P., MIKHAYLOV, YU. A., SKLIZKOV, G. V. and FEDOTOV, S. I., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR

[Abstract] An x-ray schlieren technique is proposed for quality control of shell targets in laser-driven fusion experiments using a two-crystal diffractometer. The operating principle of the method is explained on the basis of the geometric optics approximation, and it is shown that an x-ray analog of the optical schlieren method or dark-field method can be set up. In using the proposed technique for inspecting shell targets, coarse flaws are detected on the basis of symmetry and homogeneity, and the most uniform shells are checked by determining thickness. It is shown that an arrangement with asymmetric reflection produces a magnified image enabling measurement of thinner shells with greater accuracy. Experiments show that this technique can be used to determine the thickness of shells as thin as 3  $\mu\text{m}$  with an accuracy of  $\pm 0.15 \mu\text{m}$ . The authors thank Academician N. G. Basov, Professor O. N. Krokhin and Professor D. Unangst for continued interest and support of the work, and also Yu. A. Merkul'yev for providing the targets and for useful discussion. Figures 7; references 13: 5 Russian, 8 Western.

USSR

DIFFERENTIAL CROSS SECTIONS OF DEUTERON SCATTERING BY  $^4\text{He}$  NUCLEI IN THE  
DEUTERON ENERGY REGION 870-1430 keV

Moscow YADERNAYA FIZIKA in Russian Vol 29 No 5, 1979 pp 1137-1142 manuscript  
received 9 Aug 78

BARIT, I. YA., BALASHKO, YU. G., DUL'KOVA, L. S. and ZAVARZINA, V. P., Insti-  
tute of Nuclear Research, USSR Academy of Sciences

[Abstract] Elastic scattering of deuterons by  $^4\text{He}$  low-energy nuclei is of interest as a source of detailed information on the interactions occurring in a six-nucleon system. It makes it possible to compare scattering phases derived experimentally with calculations made on the basis of Schrodinger's many-nucleon equation with a realistic nucleon-nucleon potential. Different scattering cross sections of deuterons were measured in the energy range of 870-1430 keV for angles of  $38^\circ 45'$ ,  $48^\circ 54'$ ,  $60^\circ 17'$ ,  $90^\circ$  and  $125^\circ$ . Measurements for angles  $38^\circ 45'$  and  $48^\circ 54'$  were made in two ways: absolute and relative; others were only relative measurements. Absolute measurements were made with thinner input windows due to the resonance behavior of the cross section; relative measurements used the same target without an output window; the target was filled with hydrogen and helium to about 20-50 mm Hg for absolute measurements and 40-50 mm Hg for relative measurements. Parameters of  $3+$  nuclear resonance of  $\text{Li}^6$  were also determined in reactions in which the lithium nucleus is formed in its final state. Figures 2; references 12: 3 Russian, 9 Western.



USSR

ON SPONTANEOUS FISSION OF HEAVY ISOTOPES OF HAHNIUM ( $Z = 105$ ) AND OF THE ELEMENT 106

Moscow YADERNAYA FIZIKA in Russian Vol 29 No 5, 1979 pp 1149-1155 manuscript received 12 Dec 78

DRUIN, V. A., BOCHEV, B., LOBANOV, YU. V., SAGAYDAK, R. N., KHARITONOV, YU. P., TRET'YAKOVA, S. P., GUL'BEKYAN, G. G., BUKLANOV, G. V., Joint Institute of Nuclear Research, YERIN, YE. A., RYKOV, A. G., Scientific Research Institute of Nuclear Reactors, Dimitrovgrad, and KOSYAKOV, V. N., Institute of Atomic Energy, Moscow

[Abstract] Experimental research on the radioactive properties of nuclei with  $Z$  greater than or equal to 100 led to the detection of several interesting features in the behavior of their stability with respect to spontaneous fission. There is a clear maximum of periods of spontaneous fission for even-even isotopes of Fm and No as a function of the number of neutrons in the nucleus. For a heavier element, rutherfordium ( $Z = 104$ ) it was found that the strong relationship of  $T_{s.f.}(N)$  with a maximum at  $N = 152$  disappears and instead there is a smoothly increasing relationship in direct proportion to the number of neutrons in the nucleus. For Fm and No with neutron number  $N = 157$  there was a sharp rise in stability with respect to spontaneous fission. A change in the pattern of behavior of nuclear stability at  $Z = 104$  with respect to spontaneous fission according to the neutron number is qualitatively explained within the framework of dynamic calculations of spontaneous fission periods. Forbiddenness parameters for fission of odd-mass isotopes of rutherfordium are roughly identical in a rather wide range of mass numbers and amount to about  $10^4$ . Theoretical estimates of specialization energy which determines the rise in the nuclear barrier with an odd-mass particle relative to an even-even core qualitatively agree with experimental data. The cross sections of nuclear reactions may be small, but the construction of high-current heavy-ion accelerators like to U-400 in Dubna makes further work vital. Figures 4; references 21: 12 Russian, 9 Western.

USSR

ON THE MECHANISM OF ( $\pi$ ,  $\pi p$ ) REACTIONS ON LIGHT NUCLEI AT 60-170 MeV PION ENERGIES. ANALYSIS OF A 60 MeV EXPERIMENT

Moscow YADERNAYA FIZIKA in Russian Vol 29 No 5, 1979 pp 1143-1148 manuscript received 22 Aug 78

GISMATULLIN, YU. R., and LANTSEV, I. A., Leningrad and Novgorod Polytechnic Institutes

[Abstract] Earlier studies showed that with small momenta of residual nuclei in reactions  $A(\pi^+, \pi^+p)B$  and  $A(\pi^+, \pi^0p)B$  at energies of 60 MeV, the process of direct knock-on of a nucleon by a pion is dominant. This conclusion is based on results of analysis of test data in a program to identify the polar mechanism. Less clarity has been achieved about the nature of formation of the high pulse component of recoil nuclei. Consideration of the Feynman diagram with pion scattering by a heavy nuclear fragment does not permit the description of the entire set of experimental data related to the region of large momenta. Research showed that the direct knock-on model with consideration of the nucleus satisfactorily describes the reactions ( $\pi^+$ ,  $\pi^+p$ ) and ( $\pi^+$ ,  $\pi^0p$ ) in light nuclei at pion energies of 60 MeV. The share of indirect processes is significant and is greater in the reaction of charge-exchange scattering of  $\pi^+$ -mesons with emission of a proton. Figures 6; references 13: 9 Russian, 4 Western.

USSR

MEASUREMENT OF THE TOTAL NEUTRINO INTERACTION CROSS SECTION IN THE ENERGY  
INTERVAL 2-30 GeV BY MEANS OF THE SCAT CHAMBER

Moscow YADERNAYA FIZIKA in Russian Vol 29 No 5, 1979 pp 1263-1205 manuscript  
received 24 Oct 78

BARANOV, D. S., BUGORSKIY, A. P., VOLKOV, A. A., VOLKOV, G. G., IVANILOV, A.  
A., KONYUSHKO, V. I., KORABLYOV, V. M., KOROTKOV, V. A., KOCHETKOV, V. I.,  
KUZNETSOV, YE. P., KURBAKOV, V. I., MAKEYEV, V. V., MUKHIN, A. I., MYAGKOV,  
A. G., PARSHIKURA, S. N., POLYARUSH, A. YU., RYABOV, YU. G., SAMOYLOV, A. V.,  
SVIRIDOV, YU. M., SMIRNOV, YU. I., SOKOLOV, A. A., Institute of High Energy  
Physics, Serpukhov, and NIKITIN, YU. P., Moscow Engineering Physics Institute

[Abstract] Twenty-five thousand photographs were made in the SCAT chamber  
placed in the Serpukhov neutrino beam with total incidence of  $5 \times 10^{16}$  pro-  
tons on the target. The SCAT chamber was filled with freon bromide. The  
visible volume of the chamber was  $5.4 \text{ m}^3$ , effective volume being equal to  
 $2.2 \text{ m}^3$ . The reaction  $\nu_\mu + N \rightarrow \mu + \text{hadrons}$  was studied. Total resolution in neu-  
trino energy analysis in this experiment was  $\Delta E_\nu / E_\nu = 18\%$  and was almost  
constant in the entire range of neutrino energies. To reconstruct the en-  
ergy spectrum of neutrinos, the method of direct calculation of neutrino  
flow according to measured yields of pions and K-mesons from the target of  
the Serpukhov neutrino channel was used. The sharply falling spectrum in the  
neutrino energy interval of 8-12 GeV and the final resolution of neutrino en-  
ergies leads to distortion of the distribution of observable neutrino energy  
events. Based on the normal distribution of errors and the theoretical dis-  
tribution of neutrino energy events, a Monte Carlo method was employed to  
derive the correction function necessary to deduce the cross section of the  
 $\nu_\mu N$  interaction from experimental data. Figures 3; references 7: 3 Russian,  
4 Western.

USSR

INVESTIGATION OF PRODUCTION OF LEPTONIC  $\mu^-e^+$  PAIRS IN A NEUTRINO EXPERIMENT  
IN THE SCAT CHAMBER

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received 24 Oct 78

BARANOV, D. S., VOLKOV, G. G., IVANILOV, A. A., KONYUSHKO, V. I., KORABLYOV,  
V. M., KOROTKOV, V. A., KUZNETSOV, YE. P., MAKEYEV, V. V., MYAGKOV, A. G.,  
PARSHIKURA, S. N., POLYARUSH, A. YU., RYABOV, YU. G., SMIRNOV, YU. I.,  
SOKOLOV, A. A., Institute of High Energy Physics, Serpukhov, and NIKITIN,  
YU. P., Moscow Engineering Physics Institute

[Abstract] Based on material obtained in the SCAT chamber (filled with freon  
bromide with bombardment of  $4.9 \times 10^{16}$  protons on the target of the Serpukhov  
neutrino channel), the formation of electrons and positrons in  $\nu_\mu N$  interac-  
tions was studied at energies of  $E_\nu = 2-30$  GeV. Criteria by which two-lepton  
events or are not related to charmon formative processes are the following  
kinematic characteristics of two-lepton events: 1) ratio between muon and  
positron momenta; 2) correlation between directions of transverse momenta  
of the muon, positron and hadrons; 3) present or absence in the reaction of  
an associated strange particle; 4) localization of the decay peak of a  
charmed particle (or heavy lepton). Figures 3; references 12 (Western).

USSR

SEARCH FOR EVENTS KINEMATICALLY DIFFERENT FROM FISSION, RESULTING FROM NUCLEI  
 $^{238}\text{U}$  AND  $^{197}\text{Au}$  EXPOSED TO A 1 GeV PROTON BEAM

Moscow YADERNAYA FIZIKA in Russian Vol 29 No 5, 1979 pp 1241-1243 manuscript  
received 10 Oct 78

ANDRONENKO, L. N., VAYSHNENE, L. A., GORSHKOV, B. L., KOVSHEVNYY, G. G.,  
SEMENCHUK, G. G., SOLYAKIN, G. YE. and CHESTNOV, YU. A., Leningrad Institute  
of Nuclear Physics of USSR Academy of Sciences

[Abstract] Macrofol detectors have been used to measure cross sections and  
free-path characteristics of nuclear fission fragments of uranium, gold and  
silver under the influence of protons with energies of 12.2, 14, 18 and 23  
GeV. The use of detectors having a threshold of 16 atomic units covers the  
range of fragment masses of all nuclei studied. In analyzing the distribu-  
tions through the angle of dispersion between paired tracks for all nuclei,  
a group of events was isolated in the range of angles  $180-150^\circ$  which is con-  
nected with the fission channel. An attempt was made to detect the existence  
of this channel by irradiating nuclei of U, Au and Ag with 1 GeV protons and

record paired decay products using Si(Au) semiconductor detectors. Experiments supported the conclusions about the presence of events kinematically distinct from fission for nuclei of Au where  $E_p$  is greater than 1 GeV. The detection of these events at proton energies below 1 GeV and the similar spectra of angular correlations may be seen as an indication of the identity of their mechanisms of formation. Figures 2; references 5: 2 Russian, 3 Western.

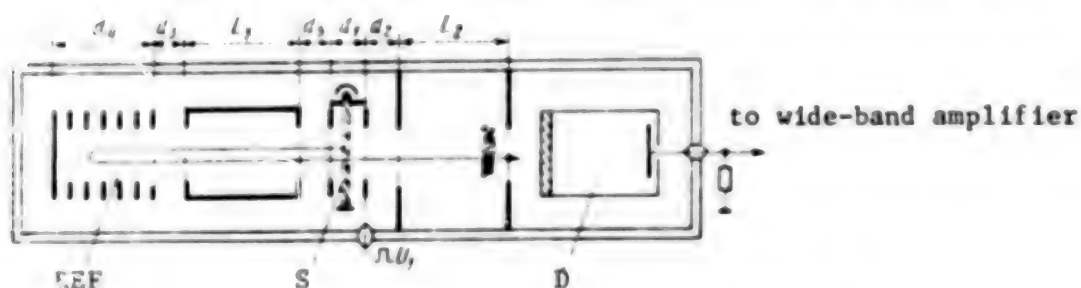
USSR

#### A LINEAR MASS-REFLECTION

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 76 No 5, May 79 pp 1500-1505 manuscript received 2 Dec 77, after revision 3 Oct 78

MAMYRIN, B. A. and SHMIKK, D. V., Physicotechnical Institute imeni A. F. Ioffe, Academy of Sciences USSR

[Abstract] The paper describes a new magnetless high-resolution time-of-flight mass spectrometer--the linear mass-reflectron. The instrument operates on the principle of compensation of the difference in time of flight by ions of different energies in field-free space, using a system of electrostatic fields for space-time focusing of ion bursts in the plane of the detector input. The instrument is shown schematically in the diagram.



The ions move along trajectories parallel to the axis of the analyzer chamber, eliminating the disadvantages of the mass-reflectron with V-trajectories of ion motion. The ions formed in ionization chamber  $d_1$  of source S are expelled by a square pulse of voltage  $U_1$ , accelerated in the first acceleration gap  $d_5$ , pass through the first field-free drift space  $L_1$ , are reflected in reflector REF (gaps  $d_3$  and  $d_4$ ), pass through drift space  $L_1$  and the source in the reverse direction, go through the second drift space  $L_2$  and are incident on detector D. The resolution of the device is calculated. Results of measurements on an experimental instrument are given. It is shown that when

the ion drift is 0.6 m the instrument has a resolution of the order of 1200 with respect to linewidth at half-height. The proposed design is applicable to miniature mass spectrometric instruments with high resolution and sensitivity. Figures 4; references 6 (Russian).

USSR

RELATION BETWEEN THE CRITICAL SPIN AND ANGULAR VELOCITY OF A NUCLEUS IMMEDIATELY AFTER BACKBENDING

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 76 No 5, May 79 pp 1506-1514 manuscript received 29 Nov 78

NOSOV, V. G. and KAMCHATNOV, A. M., Institute of Atomic Energy imeni I. V. Kurchatov

[Abstract] The relation between the angular momentum and angular velocity of aspherical nuclei immediately after backbending when  $J = J_c + 0$  is the same as at the limit  $J - J_c \rightarrow \infty$ . This is an indication of compensation for deviations of the moment of inertia from the solid-state value in the upper phase  $J > J_c$ . An integral relation is found that expresses this compensation in quantitative form. This formula is used to calculate  $J_c$  for investigated rotational bands of even-even nuclei, and the results agree with other methods of determining the position of the Curie point. Compensation of inverse values of the moments of inertia of the true and solid-state cases is verified directly in the case of the valence band of tungsten-170. The authors thank I. M. Pavlichenkov for discussing the results of the work. Figure 1; references 9: 5 Russian, 4 Western.



## COHERENT ACTIVE SPECTROSCOPY OF OPTICALLY ISOTROPIC MEDIA MADE UP OF RANDOMLY ORIENTED ELEMENTS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 942-954 manuscript received 30 Jun 78

ASLANYAN, L. S. and KOROTEYEV, N. I., Moscow State University imeni M. V. Lomonosov

[Abstract] An analysis is made of the peculiarities of using coherent active Raman spectroscopy to study the vibrational spectra of media formed by randomly oriented elements. Such media include gases and liquids in which the molecules are randomly oriented in space in the absence of an external field, and also finely dispersed systems that are optically isotropic on the whole by virtue of uniform distribution of their elements, even though these may be macroscopic anisotropic crystals. The method of irreducible tensor operators is used to get an exact expression for the macroscopic tensor of cubic susceptibility of such media. The results are expressed in terms of invariants of the molecular tensor of hyperpolarizability. Purely rotational and vibrational-rotational molecular transitions are considered. The conditions that maximize the intensity of the active Raman scattering signal are determined for a finely dispersed medium--crystalline gypsum powder. A separate investigation is made of the process of active Raman spectroscopy in a powder of crystals without central symmetry, where a cascade process may occur with participation of second-order nonlinear susceptibility in addition to the direct four-photon process involving third-order nonlinear susceptibility. The part played by depolarized waves in signal excitation with active Raman spectroscopy in a powder is considered, and an expression is given for the intensity of the anti-Stokes signal stimulated by naturally polarized light. The authors thank S. A. Akhmanov for detailed discussion of the results, A. F. Bunkin and S. G. Ivanov for assistance with the experiment, R. Yu. Orlov and A. A. Ivanov for discussing the particulars of the "power technique." Figures 2; references 16: 10 Russian, 6 Western.

## EXPERIMENTAL STUDY OF THE SPATIAL STRUCTURE OF THE FIRST STOKES COMPONENT OF STIMULATED RAMAN SCATTERING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 996-1003  
manuscript received 14 Jul 78

ANDREYEV, N. F., BESPALOV, V. I., KISELEV, A. M. and PASMANIK, G. A., Institute of Applied Physics, Academy of Sciences USSR, Gor'kiy

[Abstract] An investigation is made of transformation of single-mode collimated beams of laser emission to the first Stokes component for various incident fields above the threshold of incidental Raman scattering. It is shown that after the threshold is passed, the divergence of the Stokes wave increases sharply, and the contribution that the wave traveling into the far zone makes to paraxial intensity is determined by the comparatively small portion of the laser pulse with power below the threshold value. When the threshold is slightly exceeded, the Stokes component is a divergent wave with close to spherical wavefront. Its divergence can be reduced to the diffraction level by using a positive lens after the Raman cell with focal length coinciding with the center of curvature of the phase front. Beyond a certain level, the Stokes wave is multimodal, and divergence cannot be reduced to the diffraction level by a lens. In the case of pumping by a multimodal beam, the divergence of the Stokes wave of the incidental stimulated Raman scattering increases when the threshold is surpassed only for large-scale and small-scale laser beam modulation. In the intermediate case, the divergence of the Stokes wave is close to the pumping divergence up to double the threshold level. It is also shown that with a reduction in the scale of transverse modulation of the laser beam there is a reduction in the relative role of four-photon interaction, resulting in a drop of relative intensity of anti-Stokes radiation and a rise in Stokes radiation. Data are given on amplification of a Stokes wave close to single-mode in the field of a focused multimodal pumping beam. It is shown that there is an optimum laser beam power at which the coefficient of conversion of energy to a Stokes wave with divergence close to the diffraction level reaches its highest value. The authors thank A. A. Babin and A. A. Betin for assistance with the experiment. Figures 6; references 11: 10 Russian, 1 Western.

USSR

UDC 620.179.162

PHOTON ECHO AS A METHOD OF CRYSTAL SPECTROSCOPY (SURVEY)

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 30 No 4, Apr 79 pp 581-611 manuscript received 12 Jun 78

SAMARTSEV, V. V.

[Abstract] An echo signal is the coherent response of a resonant system to the action of two or more stimulating pulses separated by a delay. These signals were first experimentally detected in the nuclear spin system. A later development was the Carr-Purcell method of multiple-pulse stimulation of resonant systems where the echo signals are generated in the pauses between pulses. Subsequent observation of echo effects in radio spectroscopy extended the method to EPR techniques. Later theoretical analysis and experimental research with ruby crystals showed that echo signals are generated in the optical band as well (photon echo). This survey brings together the literature devoted to experiments on the physics of the photon echo effect and the possibilities of applying it to optical spectroscopy, as well as theoretical research dealing with the peculiarities of the formation of echo effects and their relation to phenomena of superluminescence. Methods of stimulating photon echo signals are discussed, and it is shown how relaxation and random processes influence the intensity of the photon echo. An analysis is made of echo signals in multilevel and degenerate systems. Photon echo and other optical transition effects are considered as methods of studying gases, semiconductors and molecular crystals. Some possible applications of echo effects are in high-speed memory cells of optical computers, optical delay lines, resonant dynamic holography and visualization of acoustic fields. Figures 15; references 163: 79 Russian, 84 Western.

USSR

UDC 551.593.652/.653

SPECTROSCOPIC STUDIES OF NOCTILUCENT CLOUDS IN THE VISIBLE REGION OF THE SPECTRUM FROM THE SALYUT-4 ORBITING SCIENCE STATION

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 30 No 4, Apr 79 pp 62-675 manuscript received 10 Jul 78

BELYAYEV, B. I., KISELEVSKIY, L. I., KLIMUK, P. I., KOKSHAROV, I. I., LOVCHIKOVA, L. P., PLYUTA, V. YE., SEVAST'YANOV, V. I. and SERGEYEVICH, V. N.

[Abstract] A report on observational data accumulated in the summer of 1975 on the Salyut-4 program of visual and spectroscopic measurements of noctiluculent clouds over a broad spectral range. The measurements in the visible region were done on the MSS-2 spectrometer designed for recording spectra in a periodic scanning mode at wavelengths of 0.4-0.8  $\mu\text{m}$ . Analysis of these spectra showed maxima of spectral brightness in the blue region at 0.43-0.46

$\mu\text{m}$ , and in the red at  $0.74 \mu\text{m}$ , the peak in the blue region being much more pronounced. Increasing brightness with a reduction in scattering angle takes place chiefly due to intensification of scattering in the blue part of the spectrum. As the scattering angle increases, the shortwave maximum shifts toward longer waves. This shows that the scattering index depends on the wavelength of the scattered radiation. Molecular absorption bands corresponding to  $\text{O}_2$ ,  $\text{O}_3$  and  $\text{H}_2\text{O}$  are observed. The bands at  $0.43$  and  $0.52 \mu\text{m}$  are of solar origin and are due to absorption of ionized iron and magnesium. Figures 3; references 14: 11 Russian, 3 Western.

USSR

UDC 535.3

#### A NEW METHOD OF CALCULATING INFRARED RADIATION OF NONHOMOGENEOUS VOLUMES OF MOLECULAR GASES

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 30 No 4, Apr 79 pp 686-693 manuscript received 6 Mar 78

VITKIN, E. I., KABASHNIKOV, V. P. and KMIT, G. I.

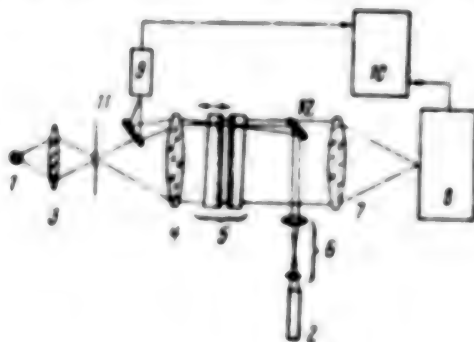
[Abstract] A method is proposed for calculating the transmission of inhomogeneous layers of molecular gases in a finite spectral interval. The method is based on introducing a distribution function  $f(\epsilon, m)$  that defines the density of spectral lines that arise in transitions from a lower energy level  $\epsilon$ , and that have a "normalized" strength equal to  $m$ . The normalized line strength in this context means that corresponding to the population of the lower level, and equal to the Loschmidt number. The positions of the spectral lines, as in the Goody model, are taken as statistically independent on the investigated spectral interval. A method is proposed for determining the distribution function  $f(\epsilon, m)$  from an experiment. The experimentally determined zeroth and first moments with respect to  $m$  for the distribution function are used to calculate the radiation of a hot layer of water vapor passed through a cold layer. Figure 1; references 9: 1 Russian, 8 Western.

# REFERENCE CHANNEL IN A FABRY-PEROT SPECTROMETER FOR DETERMINING THE PATH DIFFERENCE OF INTERFERING BEAMS

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 30 No 4, Apr 79 pp 718-722

KLEMENT'YEV, V. G.

[Abstract] An examination is made of a method of measuring the path difference in a spectrometer with high-speed scanning Fabry-Perot interferometer and an additional reference channel that uses axial and off-axis monochromatic beams. A diagram of the spectrometer is shown in the diagram, the reference channel being formed by laser source 2 ( $\lambda = 632.8 \text{ nm}$ ), telescope system 6, mirrors 11 and 12, and photocell 9. Mirrors 11 and 12 are compound and form beams that differ by a small angle of incidence on the interferometer. Scanning is realized by changing the thickness of the air gap between the plates of the interferometer as one of them oscillates axially at audio frequency. Photocell 9 registers the change in overall intensity of the transmitted beams due to their interference. The electric signal observed on the oscilloscope is the sum of two pulse trains with difference recurrence rates, i.e., with a variable phase shift. The path difference is determined by measuring this phase shift. The measurement error is comparable to that of an interferometer with plane-parallel arrangement of the plates.



1--source to be studied; 2--source of the reference channel; 3,4--lenses; 5--scanning Fabry-Perot interferometer; 6--collimating system; 7--projection lens; 8--two-slot diffraction monochromator; 9--photocells of the reference channel; 10--oscilloscope; 11, 12--composite mirrors

Figures 3; references 5: 2 Russian, 3 Western.

## DEPENDENCE OF RESIDUAL PATH DIFFERENCE IN A MICHELSON INTERFEROMETER ON THE ANGULAR ERRORS OF MIRROR ALIGNMENT

Minsk ZHURNAL PRIKLADNOY SPEKTROSKOPII in Russian Vol 30 No 4, Apr 79 pp 748-750 manuscript received 23 Jan 78

PARSHIN, P. F.

[Abstract] Usually in adjusting two-beam interferometers it is assumed that visual observation of a white band is an indication of equal lengths of the interferometer arms. In this paper it is shown by analysis of the residual path difference in a Michelson interferometer that this factor is not equal to zero even in an idealized optical arrangement for a certain combination of inclinations of the mirrors and beam splitter. When the inclination of the mirrors is compensated by inclination of the beam splitter, the interfering wave fronts will be displaced despite being parallel. It is also shown that naked-eye observations of interference bands of equal thickness have subjective limitations. A formula is given for calculating path difference, and a table is given summarizing estimates for mirror displacements from zero to 30' by 5' increments. Figure 1; references 4: 3 Russian, 1 Western.



USSR

UDC 621.383.8:534

IMAGE SCANNING

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 965-971  
manuscript received 6 Jul 78

BALAKSHIY, V. I., GALANOVA, I. YU. and PARYGIN, V. N., Moscow State University imeni M. V. Lomonosov

[Abstract] Spatial control of light beams that carry an image is necessary in solving many applied problems. While it has been noted that many of the known types of light deflectors can be used for these purposes, the question of specific optical arrangements of scanning systems remains open. This paper gives the results of calculation and experimental investigation of image scanning systems based on acousto-optical interaction. A one-lens and a two-lens system are considered and compared. Experimental data are given on a two-lens image scanning system with acousto-optical cell of  $\text{PbMoO}_4$  cut along crystallographic axes XYZ. Acoustic waves propagating along the Z-axis of this crystal are stimulated by a piezoelectric transducer of 35-degree Y-cut lithium niobate. To facilitate matching of the transducer to the generator of electric wave forms, the transducer was made in the form of four series-connected sections with co-phased excitation of ultrasound. This system can scan a field of 5.8 mm with resolution of about 60 lines/mm. The authors thank L. N. Magdich for assistance with the work. Figures 4; references 4 (Russian).

USSR

UDC 621.378.33:535.89

INVESTIGATION OF THE PARAMETERS OF FLAT OPTICAL WAVEGUIDES PRODUCED BY THE ION-EXCHANGE METHOD IN GLASS

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 1043-1047  
manuscript received 28 Jul 78

ZHENKO, A. A., LYNDIN, N. M., SYCHUGOV, Y. A., TISHCHENKO, A. V. and STIPULO, G. P., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] A diffraction method was used to measure the profile of the index of refraction in a five-mode waveguide. The experimental data are used to study the way that the effective indices of refraction of TE and TM modes depend on the depth of waveguides produced in glass by ion exchange in a silver nitrate solution. It is shown that the function  $n(x) = n_0 - \Delta n[(x/d) + b(x/d)^2]$  where  $d$  and  $b$  are profile parameters gives a good approximation

of the profile of the index of refraction, enabling production of waveguides with the necessary parameters. The paper gives the results of direct measurements of the profile  $n(x)$ . A method is proposed for determining the effective thickness of diffusion waveguides with arbitrary profile  $n(x)$ , based on measuring the effective indices of refraction of TM modes alone or TE modes alone. It is shown that in virtue of anisotropy of diffusion waveguides, the previously proposed method of measuring the effective thickness from the difference  $N_{TE}^* - n_{TM}^*$  is permissible for waveguides with a small number of modes. The techniques proposed for measuring the parameters of diffusion waveguides are applicable to single-crystal waveguides as well as glass. Figures 6; references 10: 8 Russian, 2 Western.

USSR

UDC 681.142.65

#### CALCULATION OF THE OPTICAL CHANNEL OF AN ARCHIVAL HOLOGRAPHIC MEMORY

Moscow KVANTOVAYA ELEKTRONIKA in Russian Vol 6 No 5, May 79 pp 1048-1056  
manuscript received 12 Sep 78

VARCA, P. and KISS, G., Central Institute of Physics Research, Hungarian Academy of Sciences, Budapest, Hungary

[Abstract] The propagation of information by light beam through a holographic memory is considered as diffraction of light, and an investigation is made of the proper selection of optical parameters that directly influence such memory parameters as capacity, reliability and cost. Two cases are considered: an ideal system in which the optics and mechanics of displacement are error-free, and a real system where accuracy and aberration correspond to the actually realizable technical level. An analysis is made of data transfer from an input matrix with transparent and opaque cells to a matrix of photocells at the output of a holographic memory. Consideration is taken of the shape of the reference and reconstruction beams, aberration of the optical system and possible errors in addressing of subprograms. It is shown that by proper selection of the free parameters of the optical system one can get a fairly strong signal and low cross interference, which is equivalent to high reliability of this type of holographic memory. The attainable data density is 2 megabits per sq. cm, which is adequate for an archival holographic memory. Figures 4; references 7 (Western).

## REVERSIBLE PHOTODECOLORATION OF INDUCED ABSORPTION IN FIBER-OPTICS LIGHT GUIDES

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DIANOV, YE. M., KORNIYENKO, L. S., NIKITIN, YE. P., RYBALTOVSKIY, A. O. and CHERNOV, P. V., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow, Scientific Research Institute of Nuclear Physics, Moscow State University imeni M. V. Lomonosov

[Abstract] Experiments on induced absorption in gamma-irradiated glass fiber light guides have shown a reduction in the measured coefficient of absorption with an increase of optical power in the light guide at wavelengths of 0.5-1.3  $\mu\text{m}$ . This paper gives the results of a study of the observed effect of photodecoloration of induced absorption in glass fiber light guides with a core of quartz glass about 30  $\mu\text{m}$  in diameter (concentration of hydroxyl groups  $\text{OH}^-$  is  $4.7 \cdot 10^{-4}$  wt.%) and a borosilicate shell exposed to emission from a helium-neon laser with wavelength of 0.63  $\mu\text{m}$ . Gamma exposure was from a Co-60 source with a dose of 300 rad. Photodecoloration began at intensities corresponding to a power flux of about  $4 \cdot 10^{-4}$   $\text{W}/\text{cm}^2$  in the core of the light guide. Bleaching time decreases with increasing intensity of the incident light, and is about 1 s when the incident power is of the order of  $5 \cdot 10^{-6}$  W or more. At this power level, transparency on a wavelength of about 0.9  $\mu\text{m}$  increases to the initial value before gamma exposure. Figures 2; reference 1 (Russian).

## FIBER-OPTICS LIGHT GUIDES WITH LARGE CORE DIAMETER AND LOW OPTICAL LOSSES

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DIANOV, M. M., GUR'YANOV, A. N., DEVIATYKH, G. G., DIANOV, YE. M., ZHDANOV, A. A., ZACHENYUK, A. B., KONOV, A. S., KOTOV, V. M., LAPTEV, A. YU., PROKHOROV, A. M., PRYAKHINA, T. A., RUSANOV, S. YA. and TEMNIKOVSKIY, V. A., Physics Institute imeni P. N. Lebedev, Moscow, Institute of Organoelemental Compounds, Academy of Sciences USSR, Moscow, Institute of Chemistry, Academy of Sciences USSR, Gor'kiy

[Abstract] Fiber-optics light guides of quartz glass made by vapor deposition have optical losses as low as 1 dB/km in the near infrared, but manufacture is complicated, and there is a size limit on the core of about 60-80  $\mu\text{m}$ . Light guides with a quartz glass core and polymer shell are easier to

make, and cores can be made several hundred  $\mu\text{m}$  in diameter. Although the polymer shell may have losses as high as 1000 dB/km, by using large-diameter cores the total losses in the light guide can be reduced to near the level for the initial quartz glass. This paper describes a technique for making light guides with a quartz glass core about 400  $\mu\text{m}$  in diameter with a light-reflecting polymer coating applied by sterile heat sources (oxyhydrogen flame and  $\text{CO}_2$  laser). Minimum losses in a light guide with numerical aperture of 0.2 are 18 dB/km on a wavelength of 0.8  $\mu\text{m}$ . Figures 2; references 9: 4 Russian, 5 Western.

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#### INVESTIGATION OF THE PROCESS OF FORMATION OF DIFFRACTION GRATINGS ON THE SURFACE OF OPTICAL WAVEGUIDES

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SVAKHIN, A. S., SYCHUGOV, V. A. and SHIPULO, G. P., Physics Institute imeni P. N. Lebedev, Academy of Sciences USSR, Moscow

[Abstract] An investigation is made of the process of making a diffraction grating on glass by ionic etching through a mask of acid resist. A cold-cathode ion source was used with freon-14 (tetrafluoromethane  $\text{CF}_4$ ) as the working gas. It is shown that the etching rate for many materials is greater than for the acid resist. This effect can be used to make gratings with a triangular profile. The profile of the lines in the grating on the substrate depends both on the parameters that characterize the ionic etching process and on the profile of the acid-resist mask. Therefore the shape of the mask must be carefully controlled to get a grating with the desired profile. Figures 4; references 7: 5 Russian, 2 Western.

## NONDESTRUCTIVE READOUT OF HOLOGRAMS IN IRON-DOPED LITHIUM NIOBATE CRYSTALS

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GULANYAN, E. KH., DOROSH, I. R., ISKIN, V. D., MIKAELIAN, A. L. and  
MAYORCHUK, M. A.

[Abstract] Experiments were done on recording and readout of holograms on crystals of  $\text{LiNbO}_2:\text{Fe}$  on different wavelengths. The recording was done by radiation of helium-cadmium and helium-neon lasers on wavelengths of 0.44 and 0.63  $\mu\text{m}$  respectively, and readout was done by the sources used in recording and also by semiconductor and quasi-cw single-mode ruby and YAG:Nd lasers on wavelengths of 0.9, 0.69 and 1.06  $\mu\text{m}$  respectively. The diffraction efficiency of a holographic grating with period of about 4  $\mu\text{m}$  recorded in a crystal 1 mm thick on a wavelength of 0.63  $\mu\text{m}$  is 55, 50, 13 and 50% for readout by a beam with extraordinary polarization on wavelengths of 0.63, 0.69, 0.9 and 1.06  $\mu\text{m}$  respectively. The low efficiency in the case of the semiconductor laser is due to large divergence and low degree of polarization. Readout for one hour at 30 W/cm<sup>2</sup> with the YAG:Nd laser showed no traces of erasure. Measurements of diffraction efficiency of the same hologram on different wavelengths showed that photorefraction is independent of the wavelength of the readout light. Experiments on recording and readout of Fourier-hologram transparencies on different wavelengths showed the feasibility of reconstructing all recorded information by changing the angle of incidence of the readout beam. The authors thank A. V. Semenov for providing the single-mode YAG:Nd laser, and V. I. Bobrinev for constructive criticism in examination of the manuscript. Figures 2; references 6: 2 Russian, 4 Western.

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## SCATTERING OF LIGHT IN CHOLESTERIC LIQUID CRYSTALS

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 76 No 5, May 79 pp 1515-1520 manuscript received 27 Apr 78, after revision 2 Nov 78

VESHCHUNOV, M. S., Institute of Theoretical Physics imeni L. D. Landau, Academy of Sciences USSR

[Abstract] Light scattering by longwave fluctuations in cholesteric liquid crystals was studied by Stephen and Straley for the case of the low-temperature phase where spontaneous helical anisotropy is observed [see M. J. Stephen, J. P. Straley, "Rev. Mod. Phys.," Vol 46, 1974, p 617]. However, they introduced fluctuation angles of turn of the director, and assumed slow changes in these angles compared with the period of the helix. M. S. Veshchunov now shows that the non-zero harmonics of these functions are also appreciable. Scattering by fluctuations of arbitrary wavelength is considered. The author studies uniaxial fluctuations of the director  $\delta n_x = -\phi \sin \phi_0$ ,  $\delta n_y = \phi \cos \phi_0$ ,  $\delta n_z$ , where  $\phi_0 = t_0 z$ , the z-axis is directed along the axis of the helix,  $n_x = \cos \phi_0$ ,  $n_y = \sin \phi_0$ ,  $n_z = 0$ . It is shown that maxima should be observed in the scattered light spectrum at  $q = nt_0$ ,  $n = 0, \pm 1, \dots$ , with intensity that decreases with increasing  $n$ . References 7: 5 Russian, 2 Western.

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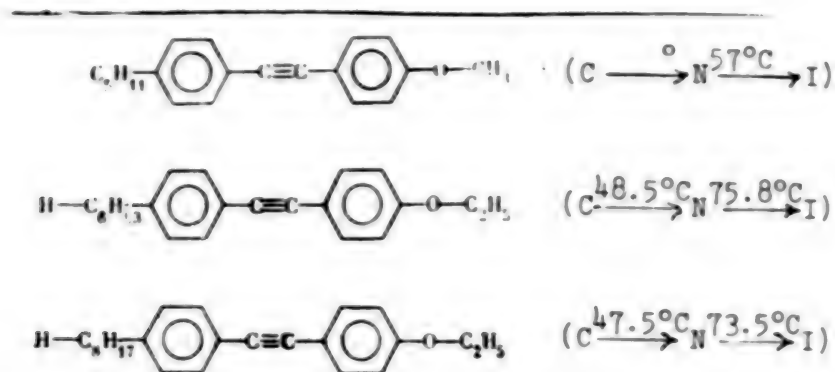
## INVESTIGATION OF ORIENTATIONAL-STATISTICAL PROPERTIES OF LIQUID CRYSTALS OF THE TOLAN CLASS BY OPTICAL METHODS

Moscow ZHURNAL EKSPERIMENTAL'NOY I TEORETICHESKOY FIZIKI in Russian Vol 76 No 5, May 79 pp 1791-1801 manuscript received 19 Dec 78

AVER'YANOV, YE. M., VAYTKYAVICHYUS, A., KORETS, A. YA., SIRUTKAYTIS, R., SOROKIN, A. V. and SHABANOV, V. F., Institute of Physics, Siberian Department of the Academy of Sciences USSR

[Abstract] Raman scattering and optical probing are used to study the orientational-statistical properties of new nematic liquid crystals of the tolan class: methoxyamyltolan, ethoxyhexyltolan and ethoxyoctyltolan. The structural formulas of the molecules are given below together with the crystal-to-nematic and nematic-to-isotropic liquid transition temperatures:





The supercooled nematic mesophase was not studied. An improved Raman spectroscopy method is proposed that eliminates the effects of multiple scattering and enables development of spectroscopic specimens with thickness comparable to the scattering wavelength. On the basis of the experimental results the authors construct orientational distribution functions for the three crystals in the independent-particle approximation. It is shown that the negative order parameter observed in the experiment is due to anisotropy of the local field of the light wave. It is shown how elongation of semi-flexible molecule segments and rising mobility of their end groups influence the orientational-statistical properties of the rigid molecular nucleus. It is found that the Maier-Saupe average field theory agrees satisfactorily with the experimental data far from the phase transition to an isotropic liquid, but is unsatisfactory for describing the orientational statistics of the metaphase in the pre-transition temperature region. The authors thank V. L. Pokrovskiy and Ye. I. Kats for discussing the work. Figures 5; references 26: 13 Russian, 13 Western.

THE COLOR AND VISUAL CONTRAST OF IMAGES ON THE THERMOCHROMIC MATERIAL  
FTIROS

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1008-1012 manuscript received 6 Oct 78

ZAKHARCHENYA, B. P., TERUKOV, YE. I., CHUDNOVSKIY, F. A., SHTEYNGOL'TS,  
Z. I., Institute of Physics and Technology imeni A. F. Ioffe, USSR Academy  
of Sciences, Leningrad

[Abstract] The material FTIROS is a parametric interference wide-band light filter which operates in reflective light. The initial color of the material, when illuminated with white light, is determined by the spectral variation of the coefficient of reflection in the visible area of the spectrum, which is primarily determined by the optical thickness of the layer of vanadium oxides of which the material is made and the structural shape of the material. An installation is described and diagrammed which was used to study the contrast and angular variation of the coefficient of brightness of the image on a specimen of the material FTIROS as a function of the thickness of the layer of vanadium oxides. These parameters are optimized for visual reading of information. The studies show that the images produced have good visual contrast and sufficient brightness that the material can be used to display information, that the phenomena involved are reversible, and that long-term memory can be achieved by the hysteresis effect upon phase transition. Figures 5; references 9: 7 Russian, 2 Western.

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UDC 620.171:778:681.778.

DETERMINATION OF THE COMPONENTS OF ELASTIC-PLASTIC DEFORMATION BY HOLOGRAPHIC INTERFEROMETRY

Leningrad ZHURNAL TEKHNIЧЕСКОY FIZIKI in Russian Vol 49 No 5, May 79 pp 1005-1007 manuscript received 16 May 78

SHCHEPINOV, V. P., YAKOVLEV, V. V., Moscow Engineering-Physics Institute

[Abstract] The solution of many problems of mechanics in which bodies are loaded beyond the elastic limit of the material, particularly in the early stages of plastic deformation, requires simultaneous knowledge of both components of the elastic-plastic deformation. These components can be determined by recording of the successive states of the surface of the deformed part during loading and unloading on different sections of a single hologram. A plan for exposure of a hologram under these conditions is outlined, and pictures of interference bands of bending of a plate recorded in this manner are presented. The method is most effective for the case in which the direction of movement is known, and is perpendicular to the surface of the deformed part, as in bending of a plate or deformation of a shell. The interferograms can be used to determine the distribution of total, residual and elastic deformation in the part. Figures 3; references 4: 2 Russian, 2 Western.

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EXPERIMENTAL STUDY OF A SUPERCONDUCTIVE LAYER ON THE SURFACE OF INDIUM AND TIN IN A LOW-FREQUENCY HIGH-AMPLITUDE ELECTROMAGNETIC FIELD

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DOLGOPOLOV, V. T. and MURZIN, S. S., Institute of Solid State Physics, Academy of Sciences USSR

[Abstract] In a hollow current-carrying type I superconductor, a layer in a two-phase intermediate state (which will be a mixed state in the limit) covers the entire inner surface of the conductor. In this layer the magnetic field jumps from zero to the critical value  $H_C$ , and the metal outside of the layer is in the normal state. The same type of layer can arise on the outside of a massive type I superconductor immediately after switching off an external magnetic field stronger than critical since the magnetic field on the surface drops to zero, but the field in the body of the superconductor exceeds the critical value until the eddy currents die out. If the magnetic field parallel to the axis of a cylindrical specimen is the sum of a constant and a low-frequency alternating component  $H = H_0 + H_1 \cos \Omega t$  with  $H_0 > H_C$ ,  $H_1 > H_0 - H_C$ , the superconductive layer will arise periodically on the outside surface. Measurements are done on the parameters of such a superconductive layer on the surface of indium and tin specimens where  $\Omega/2\pi$  ranges from 100 Hz to 200 kHz. It is shown that there is an electric field in the layer. The thickness of the layer is measured as a function of frequency. The minimum thickness is only three times the coherence length. The surface impedance of the layer is measured on a frequency of about 10 MHz in fields  $H_0$  that are parallel and oblique to the surface of the specimen. In a parallel field, the impedance of the layer is the same as that of the superconductor within 4% of the difference between the impedances of the normal and superconducting metal. In an oblique magnetic field, the curve for impedance as a function of field strength shows two experimentally distinguishable regions in which the superconductive layer has different properties. The authors thank V. F. Gantmakher and V. V. Schmidt for discussion and constructive criticism, and also A. D. Bronnikov and M. V. Zolotarev for growing the single-crystal indium plates on which some of the work was done. Figures 11; references 8: 5 Russian, 3 Western.

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